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School-based health-education programmes, health-learning capacity and child oral health-related quality of life

Ruth Freeman[a], Barry Gibson[b], Gerry Humphris[c], Helen Leonard[d], Siyang Yuan[a] and Helen Whelton[e]

[a]Dental Health Services Research Unit, School of Dentistry, University of Dundee, Scotland, UK; [b]Department of Oral Health & Development, University of Sheffield, UK; [c]Department of Health Psychology, University of St Andrews, Scotland, UK; [d]Community Dental Service, Northern Health & Social Care Trust, Antrim, Northern Ireland, UK; [e]School of Dentistry, University of Leeds, UK

Abstract

Objective: To use a model of health learning to examine the role of health-learning capacity and the effect of a school-based oral health education intervention (Winning Smiles) on the health outcome, child oral health-related quality of life (COHRQoL).

Setting: Primary schools, high social deprivation, Ireland/Northern Ireland.

Design: Cluster randomised controlled trial.

Method: 383, 7-8-year-old children were invited to participate and randomly allocated into intervention and control conditions. Baseline and 12-month follow-up assessments of COHRQoL, self-esteem, toothbrushing-fluoride toothpaste knowledge and unstimulated saliva samples were made. 18-hour post-brushing, saliva fluoride concentration was used to assess toothbrushing with fluoride toothpaste (behaviour). The data were entered onto SPSSv22. Structural equation modelling was applied using AMOSv22 to test for the role of health-learning capacity (baseline self-esteem and COHRQoL) and simultaneous effects of Winning Smiles upon knowledge, behaviour and COHRQoL (at follow-up).

Results: 238 children participated at baseline and follow-up. A partial latent hybrid model fitted the data reasonably well (χ^2= 65.6, df = 50, P = 0.07) as shown in addition by a Comparative Fit Index of 0.97 and a RMSEA value of 0.042 (90%CI: 0.00, 0.06). The intervention had a significant effect on toothbrushing-fluoride toothpaste knowledge (P<0.03) and an effect on COHRQoL at the 6% level (P<0.06). Knowledge was strongly associated with saliva fluoride concentration (P<0.002).

Conclusions: The model of health learning capacity assisted in explaining the effect of a school-based intervention upon knowledge, toothbrushing behaviour and tentatively on COHRQoL.

Keywords: health literacy, school-based oral health education, quality of life, Winning Smiles

Corresponding Author

Ruth Freeman, Dental Health Services Research Unit, School of Dentistry, University of Dundee, Park Place, Dundee, Scotland DD1 4HN

Email: r.e.freeman@dundee.ac.uk

Introduction

In 2003 Petersen published the World Health Organisation (WHO) oral health strategy (Petersen 2003). He proposed that new approaches for disease prevention and health promotion should become the cornerstones for oral health. Priority action areas (Petersen 2003, pp13), included improved and regular use of fluoridated toothpaste (MacPherson et al 2013, pp109) to reduce child oral health inequalities. However, careful examination of the findings from the global burden of oral disease studies, showed disappointing progress to reduce childhood oral health inequalities (Marcenes et al 2013). According to a modelling study conducted by to Marcences et al in 2010, untreated caries in the deciduous dentition had a global prevalence of 9% for all ages combined, or 621,507 million children affected and was the 10th most prevalent disease world-wide (Marcenes et al 2013). Moreover, the burden of untreated childhood caries in the deciduous dentition, in terms of disability-adjusted life years or years lost of health living, had increased by 5.3% from 1990 to 2010 (Marcenes et al 2013, WHO 2013a). These findings reignited Petersen's (2003) earlier calls for action to prevent childhood dental caries and the need for more effective programmes. The quest to find an effective intervention to promote child oral health and reduce inequality thus remained.

Focusing on the disappointing outcomes of preventive interventions to reduce health inequality, Phelan et al (2004) questioned the theoretical basis and formulation of health education or disease preventive programmes. They suggested that additional and predisposing factors affecting an individual's health had been largely ignored. These factors included knowledge or health literacy, and in Phelan et al's view were fundamental to health and quality of life. The fundamental factors, theorised by Phelan et al (2004) were itemised by Sørensen et al (2012) within the lexicon of health literacy as, individuals':

> 'knowledge, motivation and competences to access, understand, appraise, and apply health information in order to make judgments and take decisions in everyday life concerning healthcare, disease prevention and health promotion to maintain or improve quality of life during the life course.' (Sørensen et al 2012, pp3)

At the centre of health literacy theory (Sørensen et al 2012) is the individual's ability to understand and to use health knowledge. This ability, however, is dependent upon the individual's cognitive capabilities (e.g. verbal skills) and psychosocial skills (e.g. self-efficacy). According to Wolf and colleagues (2009) this represents the individuals' health learning capacity. Health learning capacity has some bearing on how children understand and use the health information provided to them and their capabilities to maintain their own oral health. For primary school aged children, whose cognitive skills may be less proficient, how do they understand, comprehend and use the health information provided to them? In its policy document on health literacy WHO has highlighted the role of schools as health literate settings to promote 'learning not only as a cognitive, but as an integral process with many dimensions' (WHO 2013b, pp37). We suggest, that school-based interventions, appropriately tailored to the child's educational needs could provide a health literate environment that allows the promotion of health-learning capacity, improvements in health-related knowledge, maintenance of behaviour change to affect such health outcomes as quality of life. We believe that adopting the theory of health literacy within a rubric of fundamental causes could pave the way for effective oral health interventions to reduce oral health inequalities.

DeWalt and Hink (2009) would support this proposition. They have suggested that there is a requirement, 'to identify the key health literacy skills needed by children as they transition to self-management' (DeWalt and Hink 2009, ppS273) and to use health education interventions to promote skill sets associated with health-learning capacity to promote health outcomes. Wolf et al's (2009) conceptual model of health learning, with its reliance upon health-learning capacity to improve health outcomes, such as quality of life, could therefore be used as a theoretical model to test the hypothesis that a school-based oral health education intervention, influenced by the children's health-learning capacity, could affect the acquisition of oral health knowledge, modify toothbrushing-fluoride toothpaste behaviour and improve child oral health related quality of life (the health outcome). There is some debate regarding the place of quality of life as a health outcome. Allen and Locker (2007) commented that there is an increasing recognition that health outcomes are not just about better health status but also about improving life. Therefore, quality of life and health-related quality of life measures, in their view, are important health outcomes as they reflect subjective or patient-centred health ratings. As these are known to affect adherence with health interventions they also provide a proxy measure of health-learning capacity.

The aim, of this investigation, was to use Wolf et al's (2009) conceptual model of health learning as theoretical basis to examine the role of health-learning capacity and the effect of a school-based oral health education intervention upon the health outcome, child oral health-related quality of life, for children residing in areas of high social deprivation in Ireland (Figure 1).

Method

Study design

A cluster randomised controlled trial design was adopted to evaluate the effect of the Winning Smiles school-based toothbrushing programme upon primary school children residing and attending schools in areas of high social deprivation in Dublin and Belfast. Winning Smiles used the WHO (2000) STEPwise approach and included questionnaire assessment (for example, CPQ_{8-10}), and biochemical measurement of fluoride toothpaste use (that is, 18-hour equilibrium salivary fluoride concentrations).

The sample

Primary schools in Belfast and Dublin in areas of high social deprivation were identified. In Dublin, two schools were randomly selected from the Department of Education and Science list of disadvantaged schools in the North Dublin area. In Belfast, five schools were randomly selected from schools in North and West Belfast where 50 per cent of the children received free school meals. In order to achieve sufficient numbers of children to participate and since class sizes are smaller in Belfast, more schools were sampled in Belfast than in Dublin. However this meant that additional children took part in Belfast, as it was not acceptable to the ethical committees to exclude any child within a class. The Belfast and Dublin schools were then randomly assigned to intervention and control groups using computer generated random numbers.

To evaluate the toothbrush-fluoride toothpaste behaviour using 18-hour equilibrium saliva fluoride concentrations, sample sizes of 50 children from intervention and 50 children from control schools in both Belfast and Dublin would have the power in excess of 90 per cent to demonstrate 20 per cent differences in 18-hour equilibrium saliva fluoride concentrations (two-sided tests with a 5 per cent level of significance). In addition, to enable a test of a path analytic model, the power to enable a comparison between a perfectly fitting model, where Root Mean Square Error of Approximation (RMSEA) is zero, compared to model of good fit (RMSEA of 0.06) will be 89% with 50 degrees of freedom and a sample size of 180 children (Preacher and Coffman 2006). This power calculation demonstrates that the proposed model to be tested, assuming it will possess an excellent fit, will be able to expose a model of less than good fit with this sample of children. Therefore, to ensure the ability of testing the various analytical strategies, and adjusting for clustering, it was considered prudent that the target sample size should be a total of 200, with 100 children, in their 8th year of life in Belfast and 100 children, in their 8th year of life, in Dublin study attending primary schools in areas of socio-economic deprivation with approximately equal numbers of boys and girls.

The Winning Smiles Intervention

The Winning Smiles Intervention is a school-based oral health toothbrushing programme specifically for 7-8-year-olds residing in areas of high social deprivation. It was developed as a partnership between oral health care providers and educationalists, to promote toothbrushing and fluoride toothpaste within an educational context (Freeman et al 2006). Winning Smiles used this collaborative approach to allow appropriate educational and dental health inputs from primary school teachers and oral health promoters. The oral health promoters acted as the linchpins in the negotiations with school principals and teachers to allow the implementation of Winning Smiles and ensure an integrative collaboration for the promotion of toothbrushing with fluoride toothpaste of 1450ppm in 7-8 year-old children. Winning Smiles introduced as element of competition with all children being awarded a certificate for their toothbrush prowess. Winning Smiles consisted, therefore, of an oral health promoter component, a teacher component and an award ceremony:

The oral health promoter component

This included oral health education (information on toothbrushing with fluoride toothpaste and oral health); plaque scoring (the disclosing and counting of teeth with plaque to act as baseline of toothbrushing activity) and observation of the children toothbrushing skills. The children were taught how to brush their teeth with fluoride toothpaste, how to remove plaque, and were encouraged to carry out and record a twice-daily toothbrushing regime at home over a four-week period. A simple 'plaque score' to identify the amount of dental plaque each child has on his/her teeth, was calculated, by the oral health promoter at the outset of the project. The children were asked to keep a note of their daily toothbrushing and to enter it onto the class toothbrushing progress wall chart. After the first oral health promoter visit, the children were prepared to enter the competition to have the best toothbrushing skills in their school. A second unannounced visit occurred one month later. During this second visit a second visual plaque test and a plaque score were completed as before. The results of the second plaque score were compared to the first and the children were encouraged to continue their good brushing activities, by letting them know how well they had fared both individually and collectively. At the second oral health promoter visit the Winning Smiles award ceremony was organised with the teacher.

The teacher component

The teacher acted as a support and provided additional oral health information to the children in the form of class and homework activities to promote verbal fluency, reading and numeracy. The teacher used a class toothbrushing progress wall chart to record daily the children's toothbrushing activities and supported the children's toothbrushing activities to promote their self-esteem.

The Winning Smiles award ceremony
The final part of Winning Smiles was the use of awards to encourage the children to participate. The awards served to provide a competitive element to Winning Smiles. By including competition in the structure of Winning Smiles, the children's rivalry (Freeman et al 2010) was harnessed to encourage them to brush their teeth with fluoride toothpaste. The Winning Smiles awards included:

- A toothbrushing certificate presented to all children;
- A certificate of toothbrushing achievement presented to every child that showed an improvement in toothbrushing, no matter how small;
- A medal and toothbrushing certificate presented to every child who achieved a plaque score of 0;
- The children in the class with the lowest average score for plaque in the school were awarded with a silver cup and a homework-free night.

The questionnaire
The questionnaire consisted of four parts. The first section enquired of the children's age, gender and location of school.

The second part was the 25-item Child Perceptions Questionnaire for ages 8-10 (CPQ_{8-10}) which was a compound of a composite Child Oral Health Related Quality of Life questionnaire designed at the University of Toronto (Jokovic et al 2004). The CPQ_{8-10} was used in this study to assess child oral health-related quality of life (COHRQoL). The questions assessed whether in the last four weeks the children had, as a result of their teeth or mouth, difficulty in socialising, concentrating on school work, or speaking out in class or had felt shy, worried or had been teased or questioned by other children about their teeth or mouth. The remaining questions asked whether in the last four weeks they had difficulty in eating, sleeping, talking, smiling, laughing, or had experienced pain, sore spots, pain when drinking or eating cold drinks or foods, food packing or bad breath. Responses to the questions were assessed on a 5-point Likert scale. The responses ranged from 'Never' scoring 5; 'Once or twice' scoring 4; 'Sometimes' scoring 3; 'Often' scoring 2 to 'Everyday or almost every day' scoring 1. The CPQ_{8-10} questionnaire had been subjected to a confirmatory factor analysis (Humphris et al 2005). This allowed three dimensions which reflected the concept of child oral health-related quality of life, to emerge. These three dimensions were social confidence and wellbeing, oral and social self-image and oral health awareness.

The third part of the questionnaire was the Coopersmith Self-Esteem Inventory-School Form (Coopersmith SEI-SF), for 8-15 year-olds (Coopersmith 1967). The Coopersmith SEI-SF was developed as a measure to assess children's attitudes towards themselves in general, and within particular social contexts – with regard to their relationships with peers and parents; their self-esteem in school-based situations and the extent to which their self-esteem impacts upon their personal interests. The Coopersmith SEI-SF has high reliability and validity (Chui 1985). The respondents stated whether a set of 8 favourable or unfavourable aspects of an individual were 'like me' or 'not like me'. A score of 1 was awarded to a positive response. The summation of the individual scores provided a total score for self-esteem.

Total scores range from a maximum of 8 (very high self-esteem), to a minimum of 0 (indicating very low self-esteem).

Child health-learning capacity was conceptualised as the trait self-esteem and child oral health-related quality of life as assessed by CPQ_{8-10}. The self-esteem construct contained items relating to cognitive and psychosocial skills such as attention and communication. The dimensions of the CPQ_{8-10}, reflected features of health-learning capacity in terms of child perceived self-efficacy (Pastorelli et al (2001) as well as subjective ratings of health as in the dimensions self-image and health awareness.

Assessment of toothbrushing and fluoride toothpaste knowledge was the fourth part of the questionnaire. Three questions assessed the children's knowledge of their choice of toothbrush and the use of fluoride toothpaste. The questions asked the children about why fluoride was good for teeth, how they would stop tooth decay and what type of toothbrush they would use. The questions were in yes/no format with each correct answer scoring 1. This gave a possible range of scores from 0 (no answers correct) to 3 (all answers correct).

Questionnaire administration

The questionnaire was distributed to all consented children in the intervention and control groups at baseline and 12 months. The children were asked to complete the questionnaire in class. The children were seated at their desks and discussion between the children regarding questions and answers was discouraged. To assist the children complete the questionnaire with ease, each question was read out in turn and allowed time for the children to mark their answer on their questionnaire. Time was also given to allow the children to raise their hands and ask any questions regarding any aspect of the questionnaire as it was completed. The children were encouraged to complete the questionnaire at the same time. Each questionnaire was marked with each child's individual code.

Quantitative assessment of fluoride toothpaste use: salivary fluoride levels

Research by Duckworth and colleagues had shown that the equilibrium baseline fluoride salivary concentration at 18-hour post-brushing was higher among regular users of fluoride toothpaste than among others (Duckworth et al 1992, Duckworth and Stewart 1994, Toumba and Curzon 2001). It was decided therefore to use saliva fluoride concentration as a quantitative method of assessing the children's toothbrushing with fluoride toothpaste behaviour. Unstimulated saliva samples were collected at baseline and 12-month visits. Children were asked to refrain from tooth brushing from 9.00 p.m. the previous evening on each occasion and their saliva was collected in the afternoon. For ease of collection, 4–5 children were sampled together. Between 20 and 30 samples were collected in the afternoon. The children were first asked to swallow the saliva in their mouths. Each child was then asked to expectorate saliva into a receptacle for a timed five minutes or until at least 1.5 mls. had been collected. Each receptacle was marked with subject identification number, initials, date of birth, date of sampling and time of sampling. The tubes were sealed tightly and packed in Styrofoam boxes with frozen ice packs.

To ensure standardisation the samples, were collected at the same time on each occasion. The saliva collection was taken before the children went home i.e. 1.15-3.00 p.m. and provided an equilibrium fluoride concentration at 17-18 hours post brushing. The 18-hour post-brushing saliva samples were analysed for fluoride content using the direct method (Duckworth et al 1992, Duckworth and Stewart 1994). An appropriate range of sodium fluoride standards was used. All measurements of 18-hour post-brushing saliva samples were repeated three times, taking the average of the second and third readings as the measurement result.

Coding and statistical analysis

Data were coded and entered into SPSSv22. The data were subjected to frequency distributions, correlation analysis and analysis of covariance. Analysis of covariance used baseline scores as covariates, to ensure that the differences in the outcome measure were due to the intervention and not to the control. This was necessary because in the instance where baseline values were associated with the outcome measure, using baseline scores as covariates allowed for a more precise estimate of treatment effect.

The distributions, at the various time-points, of the children's salivary fluoride levels were transformed using a log transformation, to normalise it for statistical analysis. All statistical tests on observed differences in salivary fluoride concentration levels used the log-transformed data.

Structural equation modelling using AMOSv22 tested the role of health-learning capacity (baseline self-esteem and COHRQoL) and for simultaneous effect of Winning Smiles upon toothbrushing-fluoride toothpaste knowledge and behaviour and the health outcome (CPQ_{8-12}) at 12-month follow-up), with the aid of maximum likelihood estimation. CPQ_{8-12} was introduced into the model as multi-indicator latent variables and 18-hour post-brushing salivary fluoride concentration data were introduced as a raw variable. Self-esteem and toothbrushing-fluoride toothpaste knowledge variables were entered as total scale scores. The intervention was entered as a dichotomous variable with 0 assigned as the control schools and a unity value for intervention schools.

Ethical considerations

Ethical approval for the study was obtained from the Ethics Committee of the Cork Teaching Hospitals for the Dublin study, and from Queen's University Belfast Research Ethics Committee for the Belfast study. Following a meeting with the school principal to explain the programme, the research team visited the schools to distribute written information sheets and consent forms for the children to give to their parents. The children were requested to give the forms to their parents for completion and to return them to the class teacher. The completed consents were collected by the research team and were checked for consent and for validity. Children were required to give verbal assent to participation with their right to withdraw/refuse, observed at all times.

Results

The sample

One hundred and thirty-eight Dublin children and 245 Belfast children were invited to participate in the study (Figure 2). The overall response rate at baseline was 75% (287) and was 62% (238) at 12-month follow-up. Two hundred and thirty-eight children completed the questionnaire at baseline and 12-month follow-up. A drop-out analysis showed that 10 percent (29) of children attending Winning Smiles participating schools and 4 percent (11) of children attending control schools who took part at baseline did not consent to the 12 month follow-up ($X^2[1]=1.44:P=0.23$). Similarly 8 percent (22) of children attending participating primary schools in Belfast and 6 percent (21) of children attending participating primary schools in Dublin took part at baseline did not consent to the 12 month follow-up

($X^2[1]=0.17$:$P=0.68$). Seven percent (21) of girls and seven percent of boys (19) took part at baseline but not at the 12 month follow-up ($X^2[1]=0.00$:$P=0.98$). All children (238) in Dublin (97) and Belfast (141) who completed the questionnaire at baseline and 12-month follow-up were used in the data analysis. Forty eight percent (107) were boys. Sixty-four percent (151) of the children were 8-years-old at follow-up. One hundred and seventy-nine children who completed the questionnaire at baseline and 12 month follow-up and who had provided saliva samples at baseline and 12 month follow-up were included in the structural equation modelling.

Table 1 shows the baseline the mean scores for CPQ_{8-10} for toothbrushing and fluoride toothpaste knowledge (TFT knowledge), self-esteem and baseline fluoride saliva level. There was a significant difference in COHRQoL mean scores between intervention and control schools at baseline. There were no significant differences in mean scores between intervention and control groups at baseline for self-esteem, TFT knowledge and fluoride saliva level.

[Table 1 about here]

Table 2 shows the differences in mean scores between intervention and control groups at 12-month follow-up, using baseline scores as covariates. There were significant differences between mean scores for CPQ_{8-10} ($F[1,237]=4.30$: $P=0.04$) and TFT knowledge ($F[1,237]=3.82$: $P=0.05$) between intervention and control schools with baseline values as covariates. No other statistically significant differences were shown.

[Table 2 about here]

A partial latent hybrid model (Kline 2010) was fitted that efficiently described the simultaneous effect of Winning Smiles as an intervention compared to control provision on COHRQoL (as measured by CPQ_{8-10}) and toothbrushing and fluoride toothpaste knowledge. The correlation matrix, means and standard deviations are presented in Table 3. The model was found to fit the raw data reasonably well (chi-sq = 65.6, df = 50, P = 0.07) as shown by a low chi-square value relative to the degrees of freedom (CMin/Df = 1.3), a Comparative Fit Index of 0.97 and a RMSEA value of 0.042 (90%CI: 0.00, 0.06). The number of iterations (16) was relatively small to achieve convergence. Baseline CPQ_{8-10} scores and self-esteem were entered to incorporate a more comprehensive description to reflect the Wolf et al (2009) model of health learning. The intervention was found to have a borderline effect on COHRQoL ($P<0.06$) and a significant effect on toothbrushing and fluoride health knowledge ($P<0.03$). Toothbrushing-fluoride toothpaste health knowledge had a relatively strong association with saliva fluoride concentration ($P<0.002$).

Discussion

The persistence of childhood dental caries worldwide has reignited the need for effective child oral health education to reduce health disparities and promote equality. We proposed that a school-based, oral health education programme to promote fluoride toothpaste use, underpinned by health literacy and collaborative approaches are essential for supporting child oral health outcomes. While there are many debates regarding health literacy, we have concentrated upon the process of promoting health literacy. This process driven by health-learning capacity (Wolf et al 2009), fosters an understanding of the health information provided, allows its interpretation and evaluation, so resulting in changes in health behaviour and ultimately health outcome (Sørensen et al 2012). In addition, we suggested that theoretical frameworks, which highlighted the need to address such fundamental factors as health-learning capacity, provides a model to explore the effects of a school-based oral health education programme upon child toothbrushing-fluoride toothpaste behaviour and the health outcome, child oral health-related quality of life (COHRQoL). Therefore, Wolf et al's (2009) conceptual model of health learning was used as a theoretical basis to examine the role of health-learning capacity and the effect of a school-based intervention upon the health outcome, child oral health-related quality of life (as measured by CPQ $_{8\text{-}10}$), for children residing in areas of high social deprivation.

Therefore it was of interest to note that initial findings suggested that the Winning Smiles intervention was associated not only with improved toothbrush-fluoride toothpaste knowledge, but also increases in COHRQoL at 12 months following completion of the programme, while controlling for baseline values. Careful examination of the data using structural equation modelling, however, suggested that Winning Smiles had some additional effects. Winning Smiles appeared to predict oral health knowledge, which in turn predicted improved fluoride-toothbrushing behaviours as assessed by the equilibrium fluoride saliva concentration at 18-hour post-brushing. Winning Smiles also had some affect upon child oral health-related quality of life but not to the same extent as it had upon knowledge and behaviour. It seemed that Winning Smiles acted in two ways and had two impacts - first the acquisition of oral health knowledge and improved fluoride-toothbrushing behaviour and secondly, a marginal improved, COHRQoL. Is it possible that this intervention based upon the children's tendency for competition with one-another, 'created a space' (WHO 2013b, pp37), in which the children's health-learning capacities were nurtured? Could the children's capacity to learn and engage with the programme have enabled not only an improvement in their toothbrushing behaviours but also have provided a means by which their health learning capacity could be positively affected? Tentatively, we would like to suggest that the Winning Smiles intervention may have acted in someway to support the children's emerging capability to process health information into health action.

This proposition is supported by the inclusion of the path analytical approach to test the model proposed by Wolf et al (2009). It provided a way to demonstrate the simultaneous effects of the intervention, and also to enable additional variables to be entered into the model as presented in Figure 3. It is interesting to note, that a direct pathway between behaviour (fluoride saliva level) and COHRQoL ($CPQ_{8\text{-}10}$) was insignificant, but pathways existed between the intervention and COHRQoL ($CPQ_{8\text{-}10}$) and between the intervention and health knowledge. Feinstein et al (2006) examined the evidence for the effects of education upon health and health behaviours. They suggested that there were direct effects of education on health behaviours and indirect effects upon the self. Using Feinstein et al's conceptual framework, it may be suggested that Winning Smiles had a direct effect upon behaviour through the health knowledge to health behaviour pathway and also had a lesser effect upon the self, as in the outcome COHRQoL ($CPQ_{8\text{-}10}$). The current findings, thus, partially support Wolf et al's model of health literacy, but point to the need for further conceptual work contingent upon the inclusion of the children's social and general educational experiences to understand potential mediators between health education interventions and outcome measures.

Limitations

There are limitations to this work. First, the use of proxy estimates of child health-learning capacity. Support for CPQ_{8-10} and self-esteem as proxy estimates may be found in the work of Pastorelli et al (2001). They suggested that child perceived self-efficacy was an academic-social construct, composed of the child's perceived capabilities to manage schoolwork, to interact with peers and participate in out of school activities. The three dimensions of COHRQoL (CPQ_{8-10}) (Humphris et al 2005) mirrored Pastorelli et al's (2001) concept of child perceived self-efficacy. For instance, the first factor 'social confidence and wellbeing', was loaded with items that reflected perceived capability such as concentrating on homework or participating in class; the second factor 'oral and social self-image', was loaded with items that reflected social self-efficacy such as socialising or using sports or clubs with peers and the third factor, 'oral health awareness' was loaded with items that reflected Pastorelli et al's self-regulatory efficacy – for example being questioned about teeth. Moreover the use of reliable and valid inventories, which had been carefully assessed as being educationally appropriate for children in their 8th year, allowed the effect of Winning Smiles upon health-learning capacity to be explored.

Second, there is the issue of working across different jurisdictions with different methods of assessing socio-economic status and different class sizes – all of which were potential areas for error. For instance, using free school meals in Northern Ireland and being in a receipt of a medical card (for free medical/dental care) in the Republic of Ireland acted as proxy measures of child SES. The use of such proxy measures has been questioned with regards to their ability to reflect true SES (Hobbs and Vignoles 2007). In order to reduce this potential bias, postal codes of the school environment were also used. It was noted that children in the Dublin had higher salivary fluoride levels compared with Belfast. This was attributed to the fluoridation of public water supplies in Dublin, however the increases salivary fluoride level in Dublin and Belfast intervention schools compared with control schools suggested that there had been an effect of Winning Smiles upon behaviour.

Therefore, caution is required in the interpretation of these effects as the health behaviours and quality of life ratings were self-reports, although the saliva fluoride measures were independent assessments and not open to subjective opinion. We believe this is one of the first oral health education programmes that adopted the WHO (2000) STEPwise approach and included a robust biological marker (18-hour equilibrium salivary fluoride concentration) into the evaluation system (WHO 2014).

It may be cautiously suggested that the children's health-learning capacity, the appropriateness of the health message and the inclusion of an element of competition in Winning Smiles, permitted a health literate setting to be established which reflected the children's educational and social experiences (Freeman et al 2010). Thinking in this way, it may be proposed that the use of this collaborative approach permitted the children to use their health-learning capacity, to encode the toothbrushing health message provided by their teacher and visiting oral health promoter to increase their health knowledge and support their behaviour change. Moreover, as a consequence of the acquisition of knowledge and health behaviour, Winning Smiles may have assisted in building the children's social confidence and wellbeing, their oral self-image and oral health awareness – in short the health outcome, child oral health-related quality of life. Accepting the need for caution in the interpretation of these findings, it is possible that the children's developing health-learning capacity acted as a driver in the attainment of health knowledge and its application for dental caries prevention – for Sørensen et al (2012) this would be the acquisition of health literacy. Nonetheless, the need remains for future work to uncover 'the key health literacy skills needed by children as they transition to self-management' (DeWalt and Hink 2009, ppS273). This may be achieved using a qualitative exploratory design to examine how children, in different phases of their psychological development, encode the health messages delivered to them by their teachers and parents (Freeman 2015).

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Table 1 Total baseline scores and comparisons between intervention and control groups for COHRQoL, self-esteem, TFT knowledge and fluoride saliva levels

	Total baseline scores Mean (95%CI)	Baseline scores Intervention group Mean (95%CI)	Baseline scores Control group Mean (95%CI)	t	p
COHRQoL*	109.66 (107.10, 110.01)	111.18 (108.91, 113.47)	105.72 (102.26, 109.18)	2.61	0.01
Self-esteem	6.25 (5.96, 6.35)	6.19 (5.87, 6.54)	6.08 (5.72, 6.42)	0.56	0.57
TFT Knowledge**	2.00 (1.89, 2.11)	1.95 (1.97, 2.29)	2.07 (1.83, 2.19)	1.05	0.29
Fluoride saliva level	0.0189 (0.0178, 0.0199)	0.0190 (0.0150, 0.0210)	0.0188 (0.0170, 0.0190)	0.24	0.84

*COHRQoL: Child oral health related quality of life

**TFT Knowledge: Toothbrush and fluoride toothpaste total knowledge scores

Table 2
Comparisons by intervention school status between mean scores at 12 -month follow-up for COHRQoL self-esteem, toothbrush-fluoride toothpaste knowledge, fluoride saliva level with baseline scores as covariants

	Intervention Mean (95%CI)	Control Mean (95%CI)	F(df)	P
CPQ $_{8-10}$*	113.05 (111.28, 114.82)	100.03 (107.78, 112.26)	4.30 (1,237)	0.04
Self-esteem	6.38 (6.13, 6.64)	6.07 (5.75, 6.39)	2.35 (1,237)	0.13
TFT Knowledge**	2.12 (1.98, 2.25)	1.90 (1.73, 2.07)	3.82 (1,237)	0.05
Fluoride salivary level	0.021 (0.018, 0.024)	0.018 (0.015, 0.021)	1.87 (1,178)✌	0.17

* CPQ $_{8-10}$: Child oral health related quality of life
**TFT Knowledge: Toothbrush and fluoride toothpaste total knowledge scores
✌179 children provided saliva samples at baseline and 12 month follow-up

Table 3 Correlations, means and standard deviations of child oral health related quality of life (CPQ $_{8-10}$), self-esteem, toothbrush-toothpaste knowledge, fluoride saliva level and assignment to intervention or control school.

	CPQ $_{8-10}$ (baseline)	CPQ $_{8-10}$ (follow-up)	Self-esteem (baseline)	Self-esteem (follow-up)	TFT knowledge👎 (follow-up)	Fluoride saliva (follow-up)	Intervention or Control school	Mean score	SD
CPQ $_{8-10}$ (baseline)	1							109.06	15.56
CPQ $_{8-10}$ (12 mth follow-up)	0.40**	1						111.87	11.83
Self-esteem (baseline)	0.43**	0.19**	1					6.15	1.53
Self-esteem (12mth follow-up)	0.17**	0.30**	0.25**	1				6.26	1.61
Toothbrushing and fluoride toothpaste knowledge (12mth follow-up)	0.15*	0.11	0.15*	0.18**	1			2.03	0.85
Fluoride saliva level (12mth follow-up)	0.10	0.05	0.04	0.02	0.21**	1		0.02	0.01
Intervention/ Control school⌖	0.17**	0.19**	0.04	0.10	0.11	0.11	1	N/A👎👎	N/A

⌖ Intervention=1: control=0

⚲ TFT knowledge = Toothbrushing and fluoride toothpaste knowledge

⚲⚲ N/A = not applicable

Figure 1. Wolf et al's (2009) conceptual model of health learning as applied for Winning Smiles

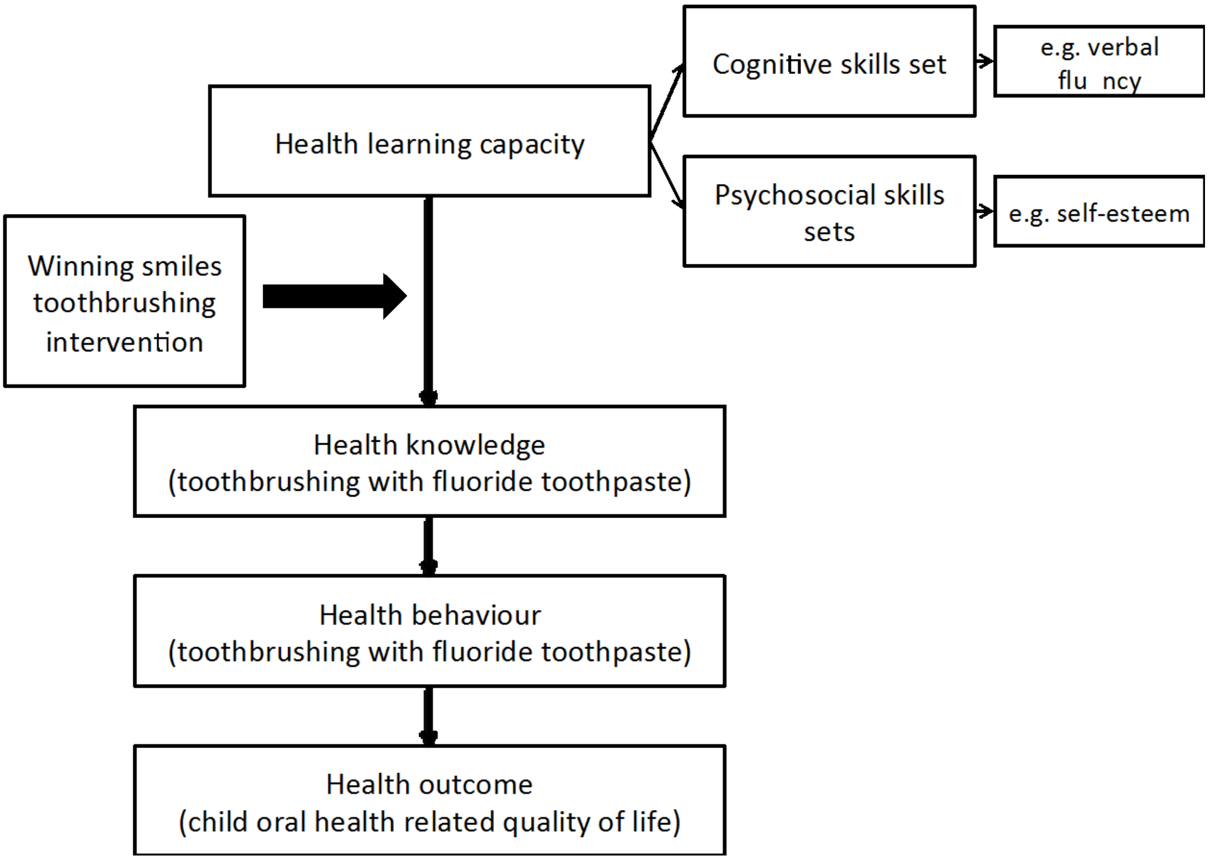


Figure 2. Profile of Winning Smiles trial

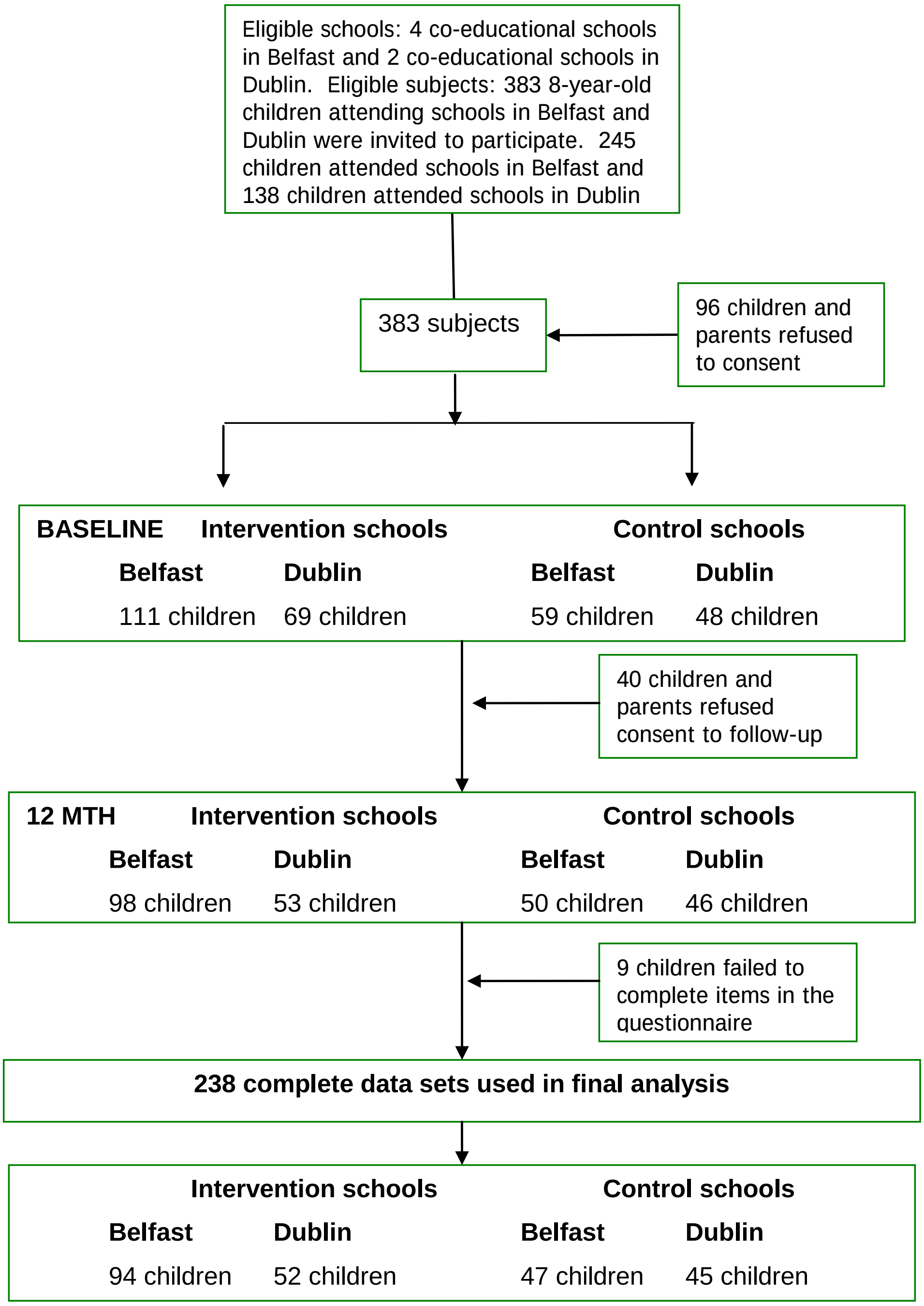
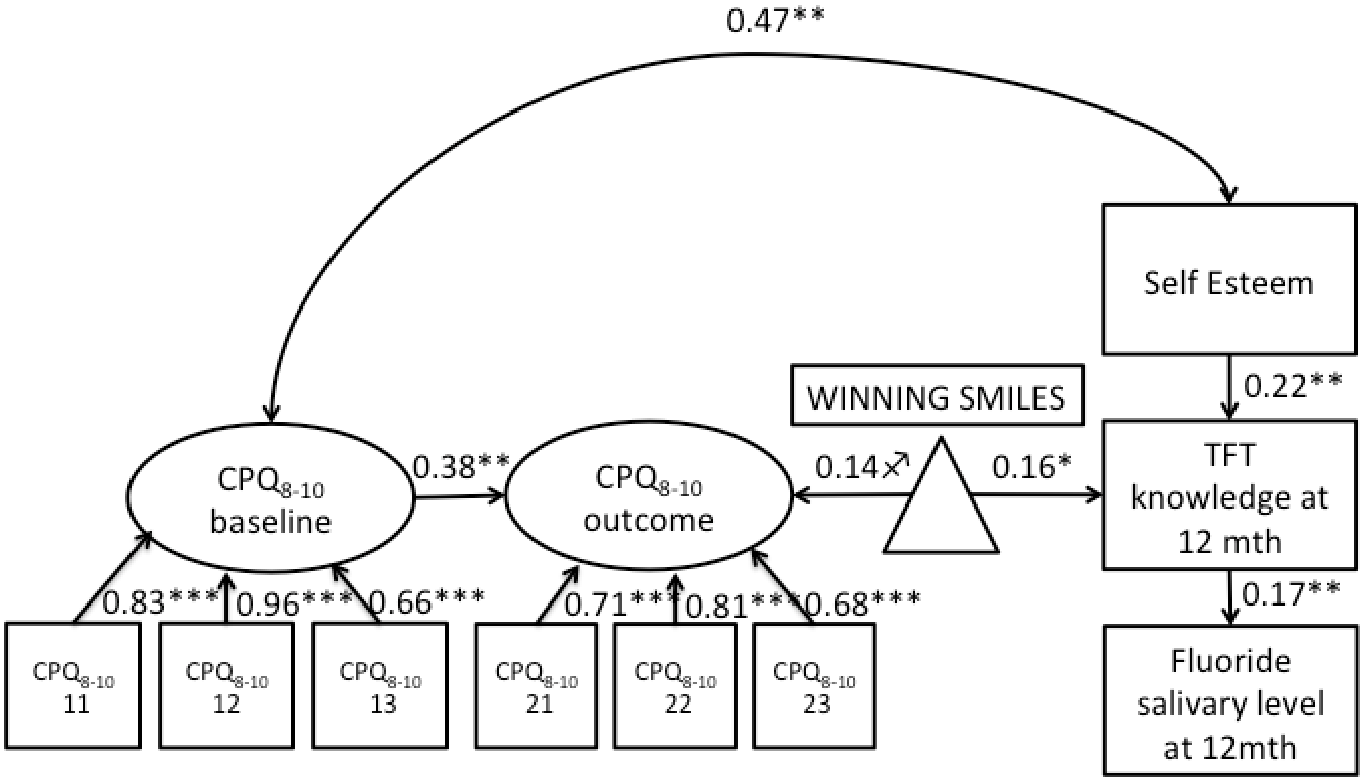


Figure 3. Partial latent hybrid model showing direct and indirect influences of Winning Smiles on child oral health-related quality of life and self-esteem (standardised coefficients)



Winning Smiles Intervention (=△)

Intervention schools=1: control schools=0

Dimensions of Child Oral Health-Related Quality of Life (CPQ_{8-10})

CPQ_{8-10} 11= social confidence and well-being at baseline: CPQ_{8-10} 21= social confidence and well-being at 12 month follow-up:

CPQ_{8-10} 12= oral and social self-image at baseline: CPQ_{8-10} 22= oral and social self-image at 12 month follow-up:

CPQ_{8-10} 13= oral health awareness at baseline. CPQ_{8-10} 23= oral health awareness at 12 month follow-up.

TFT knowledge = Toothbrushing- fluoride toothpaste knowledge (TFT knowledge)

**P<0.005: *P<0.05: □P=0.06